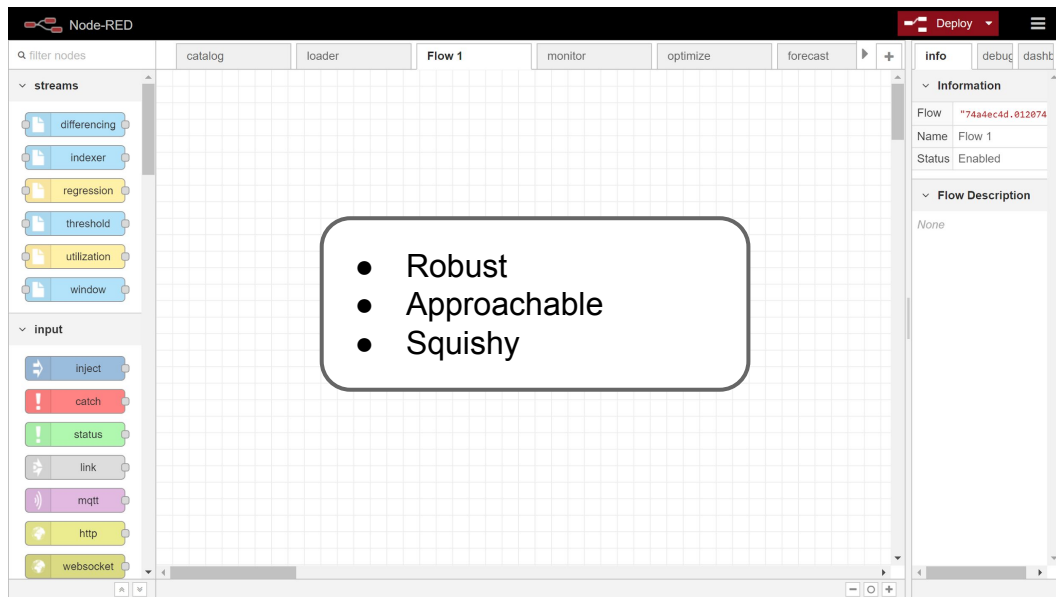


Introduction

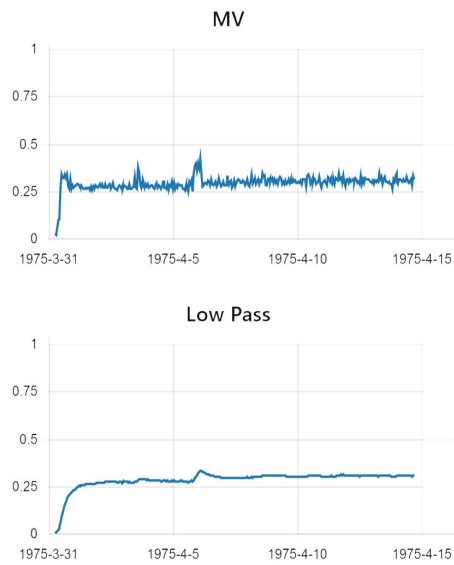
- Complex problems
- Build a model to understand a complex system
- The modeling material should have the Play-Doh Nature
- Robust
- Approachable
- Squishy



-the play-doh nature-

Introduction

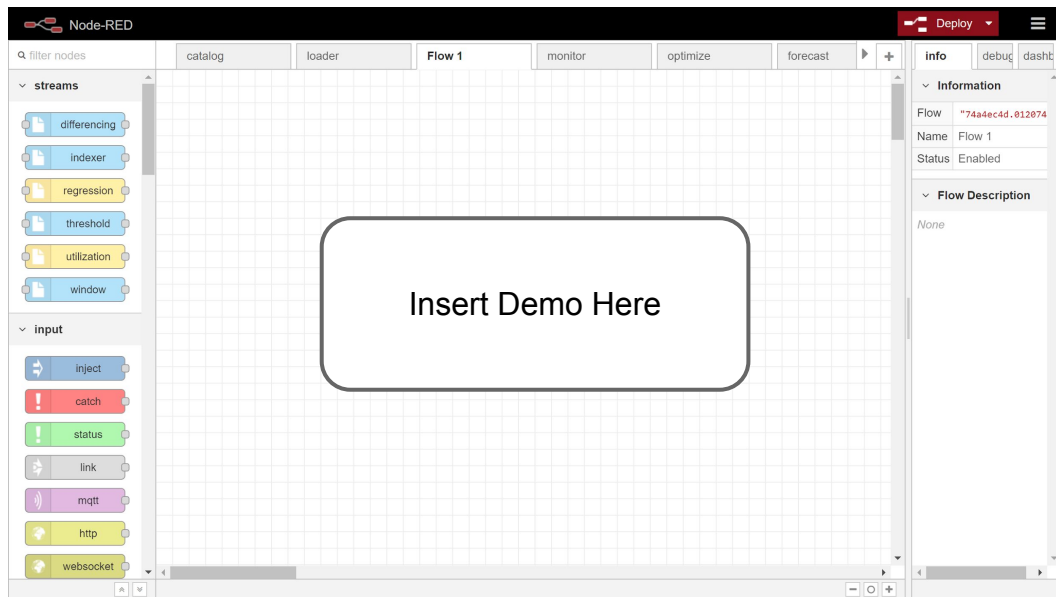
- Node-red is a flow-based programming environment for the internet-of-things
- Node-red has the Play-Doh nature
 - Robust - Provides a variety of functions
 - Approachable - Javascript and html
 - Squishy - It can be molded
- Overview of the process industries



-monitoring-

Monitoring

- A digital twin is a digital replica of a physical asset or process
- A digital twin provides three main functions:
 - Monitoring
 - Diagnostics
 - Forecasting
- Digital twin of an industrial pump

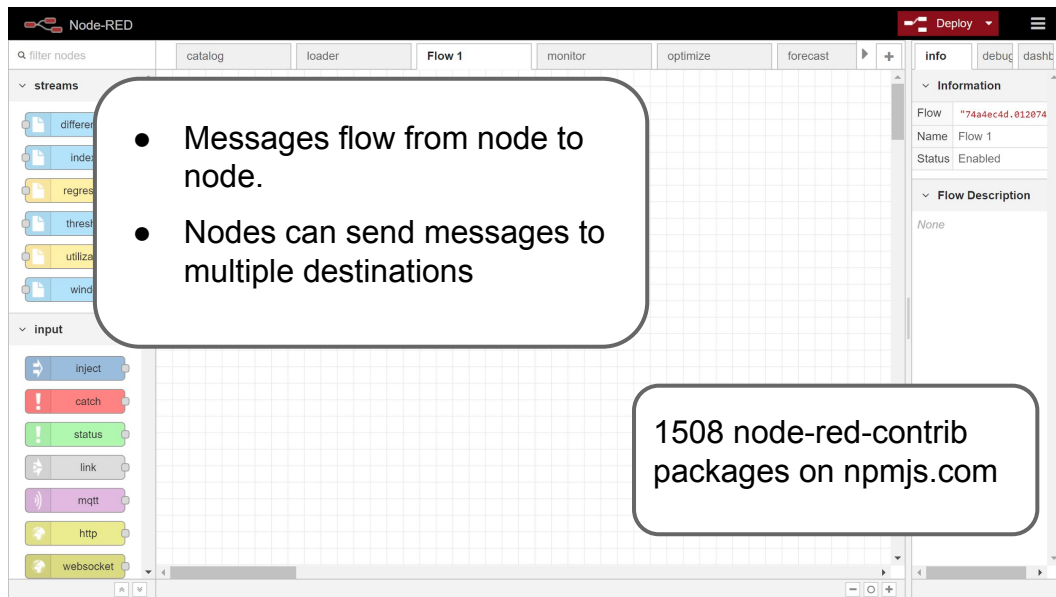


-monitoring-

Monitoring - Demo

- Decomposition functions
 - Trend
 - Seasonal
 - Residual
- A low pass filter removes the seasonal and residual components leaving the trend
- A differencing filter removes the trend component and leaves the seasonal and residuals
- **Show design surface**
- **Goto *monitor* flow**
- Basic unit of abstraction is the flow
- Messages travel from node to node over the interconnecting *wires*
- *link* node
- *graph* node

- Goto the *filter select* flow
- *Low pass* node
- Send messages to more than one downstream node
 - Duplicated
 - Routed

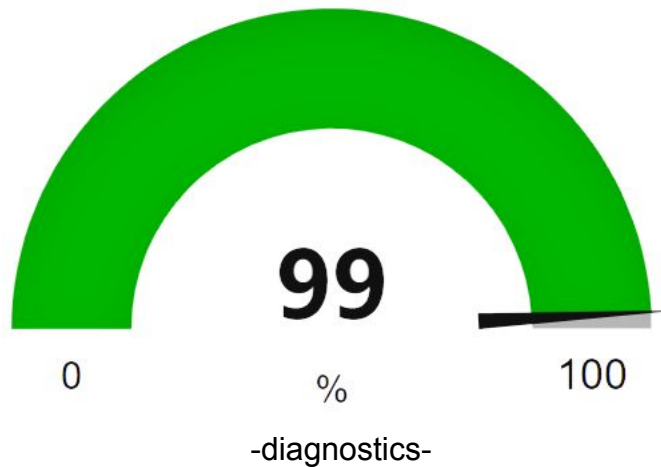


-monitoring-

Monitoring - Takeaways

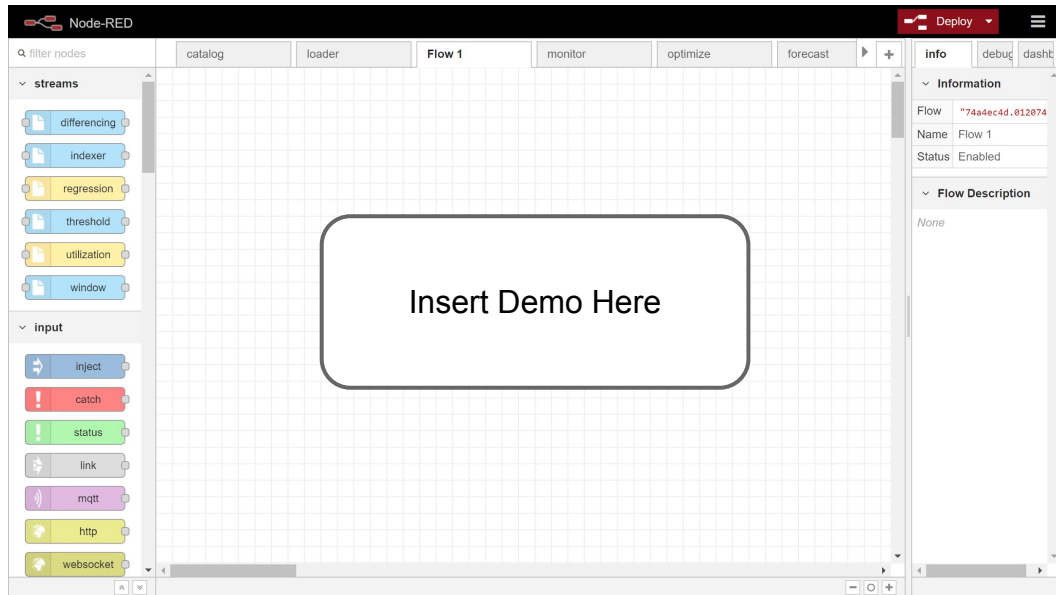
- Flow from left-to-right
- Messages have id, timestamp, topic, payload
- Nodes manipulate the messages as they pass through the node
- Messages can be sent down multiple paths
- There are 1500 packages in the npm registry that have the node-red-contrib-* prefix
- The entire functionality of this part of the model was built with out-of-the-box nodes and a couple of packages from the registry

Utilization



Diagnostics

- The diagnostics section consists of a gauge which displays utilization of the pump
- Proportion of the time that the pump is in operation
- Some pumps have signals of the operational status
- This one doesn't so we'll pick an arbitrary threshold

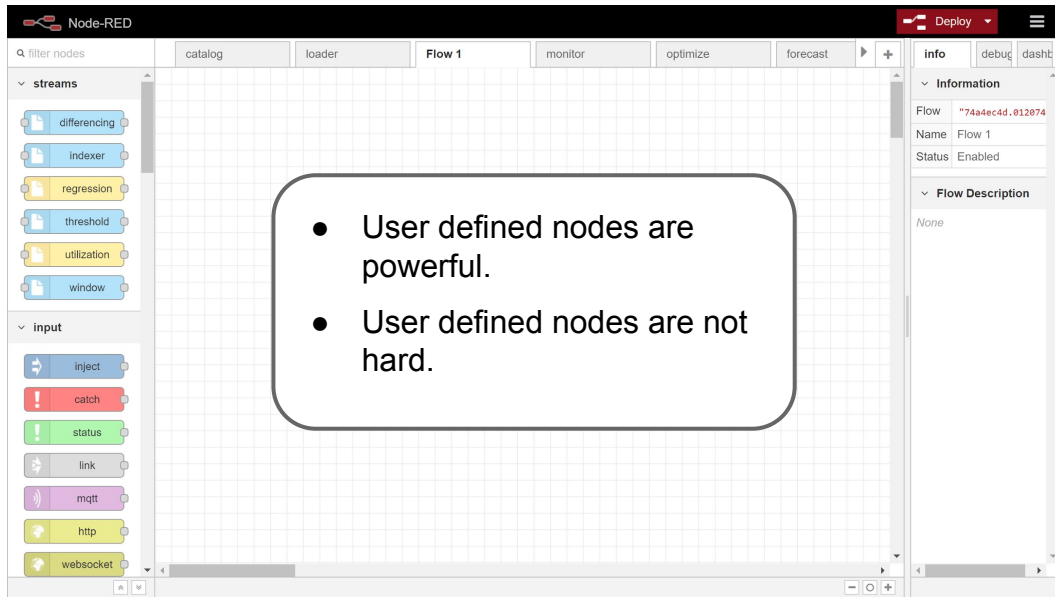


-diagnostics-

Diagnostics - Demo

- Show app
- Reset
- Select the first series
- smoothed data and calculations
- Show design surface
- Goto the *diagnostics* flow
- Utilization node
 - Calculate the KPI
- *user-defined node*
 - defined by two files - an html file and a javascript file
- Open the utilization node configuration panel
- validation, default values, and placeholder text
- Node help
 - Special behaviors
- Show code editor

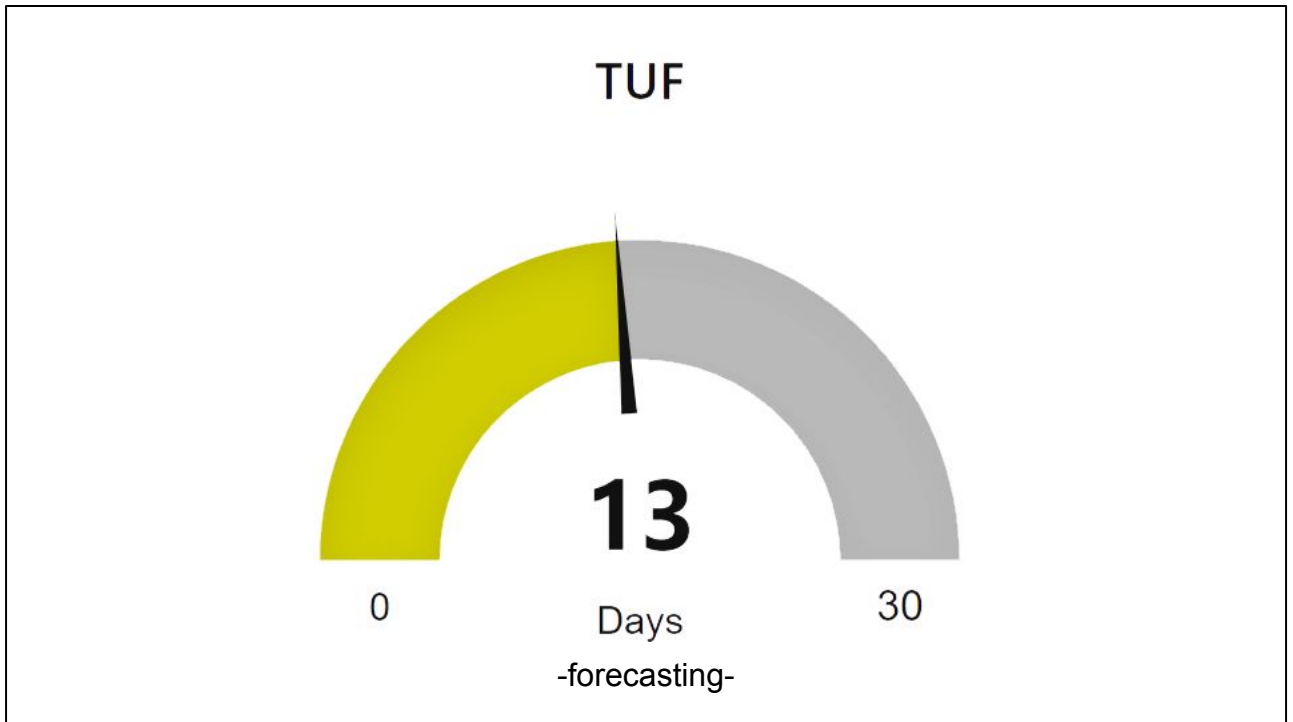
- **Open utilization.html**
- html fragment defines the form fields and the help text
- Validators use regular expressions
- life cycle callbacks.
- **Open utilization.js**
- ***Utilization*** function
 - factory
 - event listener for the ***input*** event
- event handler
 - Sums the time between messages
 - sum of the time greater than the threshold.
 - Calculate $ON\ T / TOTAL\ T$
 - Send the result downstream



-diagnostics-

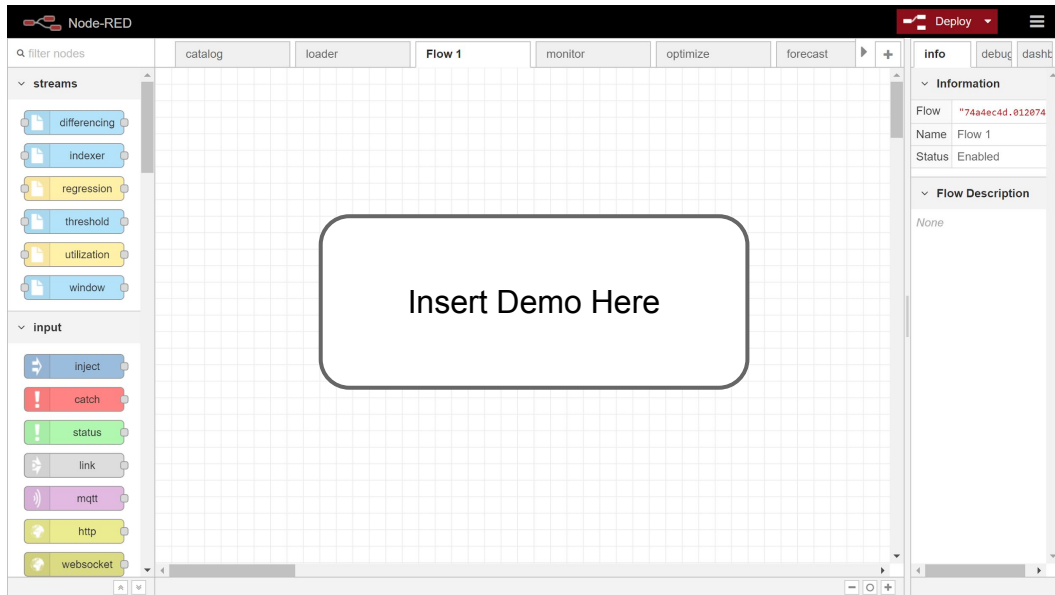
Diagnostics - Takeaways

- You can define your own nodes with their own configuration UIs
- Useful when you need multiple instances with different configurations



Forecasting

- Predict the ***time-until-failure*** for the pump
- Arbitrary threshold to indicate failure
- Signal is greater than 0.75
- Use the data to build a regression model

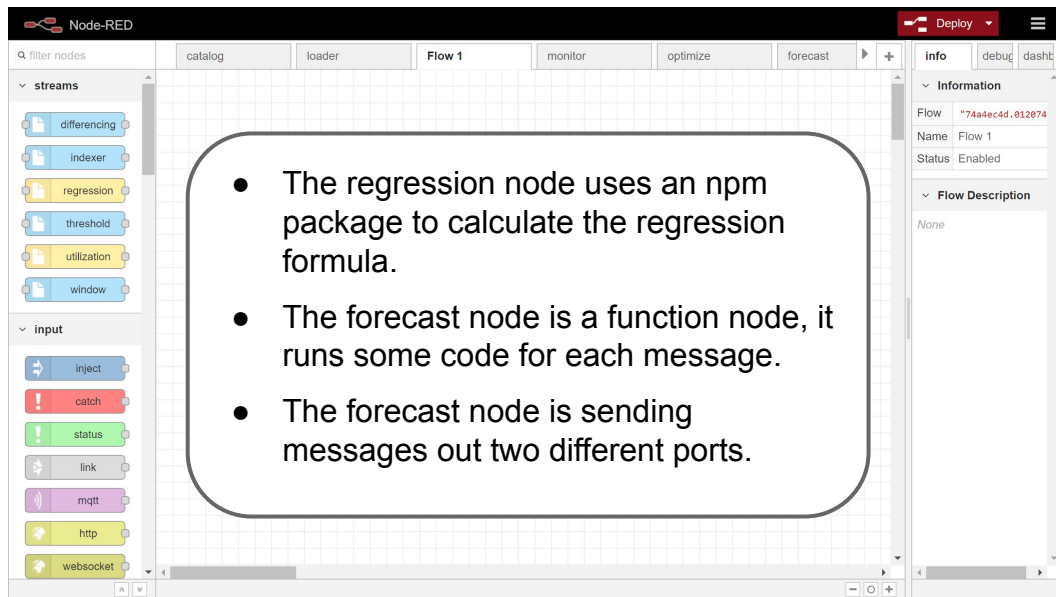


-forecasting-

Forecasting - Demo

- Show the app
- Reset
- Select the parabola series
 - Using a parabola makes it easier to visualize
- Data is sliced into windows
- Each window is used to create a linear regression
- The regression is used to predict when T will exceed the threshold
- Show design surface
- Goto the *forecast* flow
- Batch and join generate windows
 - batch adds a property indicating the message position in a group\
 - join bundles related messages into an array
- Show code editor

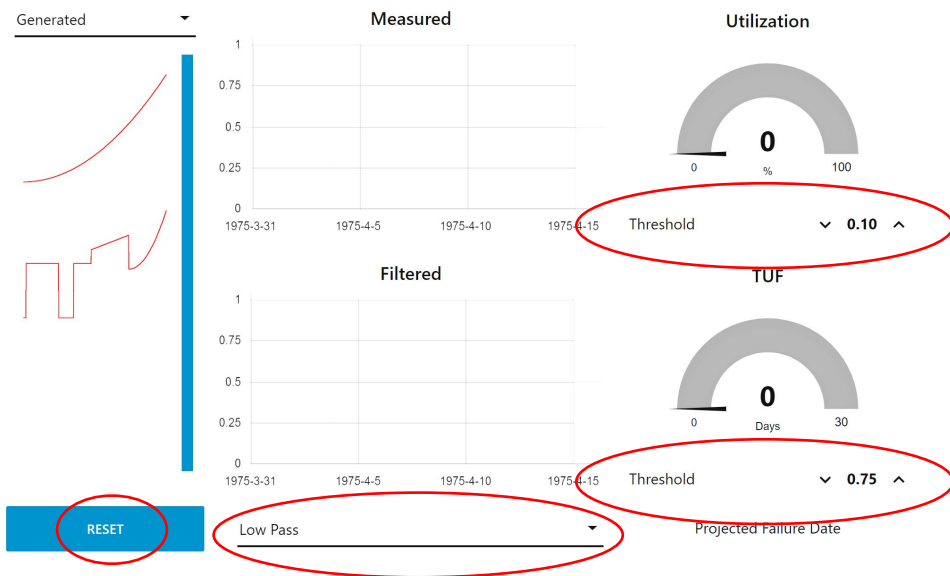
- Open settings.js, line 199
- Regression: a user-defined node using an npm package
- Packages are props on the global context
 - Flow context
 - Node context
- Open regression.js
- Event handler
 - Get the regression package
 - Map() the data into a form that the regression package needs
 - messages have timestamp and payload properties but the regression package wants a list of lists
- forecast node is a function node, ie the event handler portion of a user-defined node
 - Line 5 - using the coefficients from the regression model to calculate T
 - Line 14 - return array of messages, each message will go out a different port



-forecasting-

Forecasting - Takeaways

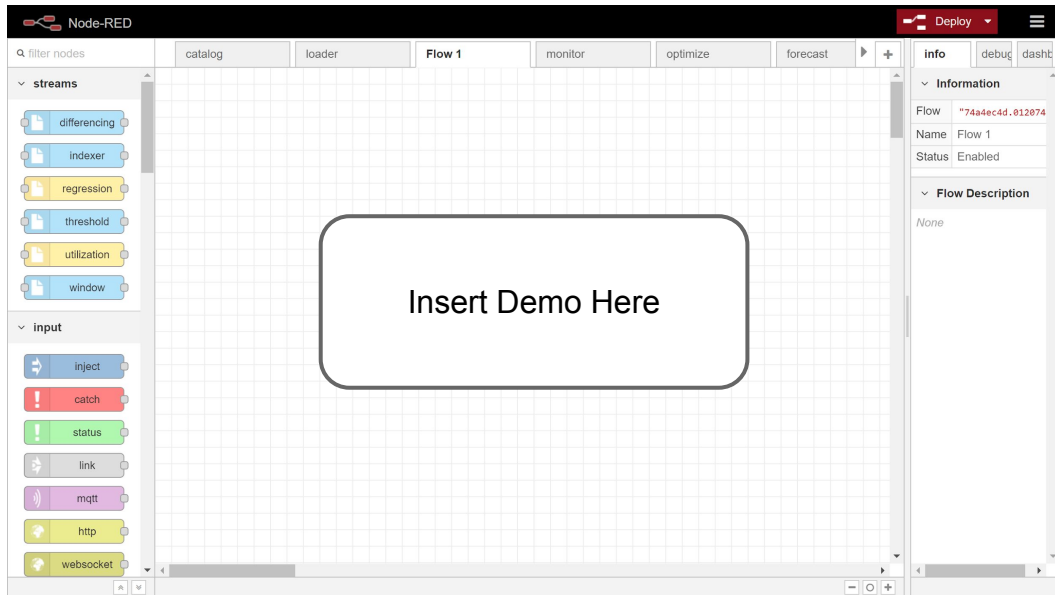
- User-defined nodes - we've already covered them.
- The regression node uses an npm package to calculate the regression model
- The forecast node is a **function** node, it runs some code for each message
- The forecast node is sending messages out two different ports



-ui components-

UI Components

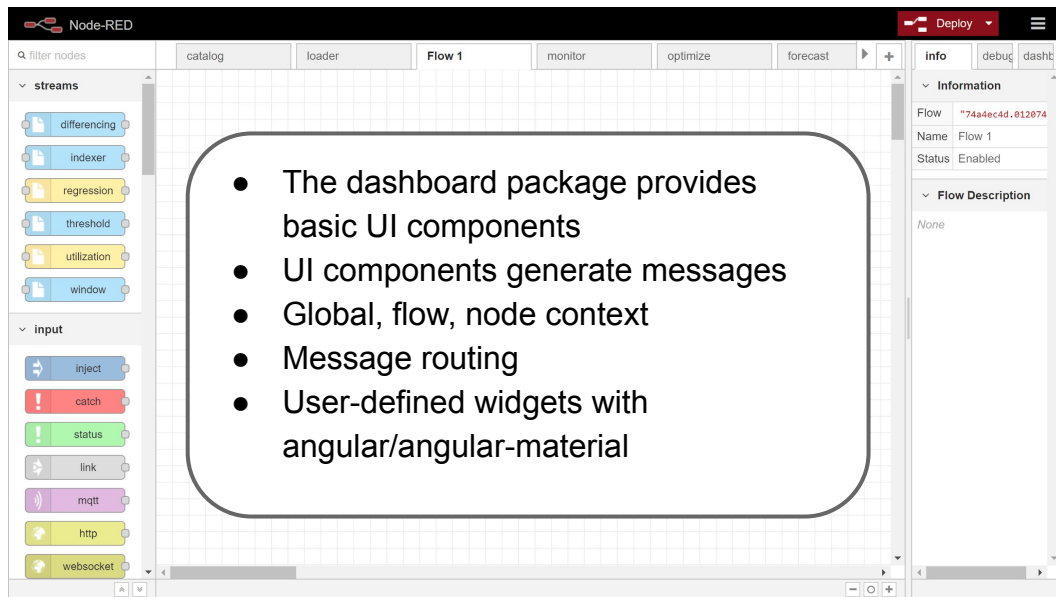
- A model with hard-coded parameters is less useful
- Dashboard package has data input nodes



-ui components-

UI Components - Demo

- **Show app**
- Numeric inputs send a message on click
- Message is made available via a link
- Function node stores the value in the context
- **Show design surface**
- **Goto filter select flow**
- Dropdown node selects a filter, sends message on change
- **Open the route node configuration panel**
- Route nodes send messages out a port based on a property
- User-defined widgets
- **Show app**
- **Scroll the time series picker**
- Dashboard package has HTML template node
 - Uses angular and angular-material directives



-ui components-

UI Components - Takeaways

- The dashboard package provides basic UI components
- UI components generate messages
- Global, flow, node context
- Message routing
- User-defined widgets with angular

Dennis Dunn

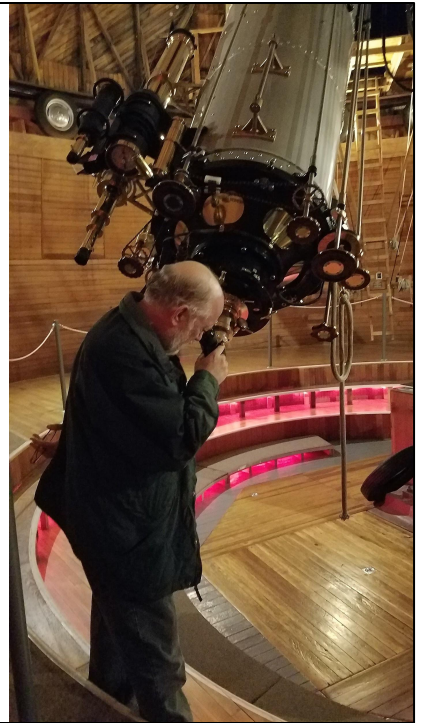
ddunn@icct.com

@ansofive

<https://github.com/dennisdunn/play-doh-nature>

<https://github.com/dennisdunn/stream-analytics-model>

TL;DR; Node-red has the Play-Doh nature.



- Node-red has the Play-Doh nature
- Messages travel down wires between nodes
- Many types of nodes are included
 - Many more are available as npm packages
- User-defined nodes have
 - Html ui
 - Javascript functions